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A1_7 That's No Exoplanet!

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Abstract

As the Death Star II passes in front of a star in the Endor system, it could be detected using the methods of transit photometry and Doppler spectroscopy, commonly used to discover exoplanets. We find that the Death Star II would cause a 1.3x10^{-6}% drop in the flux from the star, and cause the star to have a radial velocity of 1.53x10^{-7}ms^{-1}, undetectable with current technology.

Introduction

Following the destruction of the original Death Star at the Battle of Yavin, the Galactic Empire focused their efforts on the construction of the second Death Star, commonly known as Death Star II. This newer model was larger than Death Star I, at 160 km in diameter [1]. As the (completed) Death Star II passes in front of the star of the Endor system, an observer watching it a long time ago in a galaxy far, far away would see a drop in the flux of the star, similar to watching the transit of an exoplanet. We will use the transit photometry and Doppler spectroscopy methods to calculate whether the Death Star II would be detectable from an observer on Earth.

Theory

In this model, we treat the Death Star II as an exoplanet passing in front of a star, blocking some of the light, from our perspective as observers. In the field of exoplanet detection, this is known as transit photometry and is used to find the radius of an exoplanet from the dip in a light curve [2]. We rearrange this equation to find the percentage drop in the flux from the star, Δf, which can be calculated using equation (1) [3].

$$(\frac{R_p}{R_*})^2 = (\frac{\Delta f}{f_*}) \qquad (1)$$

where R_p = 80km, the radius of the Death Star II, R_* = 6.957x10^8m, the radius of the star, and f is the flux of the star before a transit. We take $\frac{\Delta f}{f_*}$x100 to be the percentage flux drop. We assume the star to be similar to our Sun, a G2V type main-sequence star [4].

Using these results, we will be able to determine whether the Death Star II would be detectable using Earth-based telescopes. If we find that it is not detectable, we will estimate the minimum size for the Death Star II to be detected based on the Kepler exoplanet detection mission capabilities.

Another method of exoplanet detection is Doppler spectroscopy, or the radial velocity method. By measuring the velocity of the parent star as it wobbles back and forth due to the orbiting body, the mass of the exoplanet, if there is one, can be inferred [5]. Again, we will rearrange the equations to find the radial velocity and determine whether it could be detected with current missions. Combining equation (2) and equation (3), we reach equation (4), which tells us the radial velocity, V_*, of the star [3].

$$V_p = \sqrt{\frac{GM_*}{r}} \qquad (2) \qquad\qquad M_p = \frac{M_* V_*}{V_p} \qquad (3)$$

$$V_* = \sqrt{\frac{GM_*}{r}}\frac{M_p}{M_*} \qquad (4)$$

where V_p is the velocity of the planet, $G = 6.67\text{x}10^{-11}$ - the universal gravitational constant, $M_* = 1.99\text{x}10^{30}$kg - the mass of the star, $r = 1.496\text{x}10^{11}$m - the orbital radius of the Death Star II, and $M_p = 1.01\text{x}10^{19}$kg - the mass of the Death Star II. We assume that the Death Star II is orbiting at 1AU from the star. We assumed that the Death Star II is a 60% solid sphere of steel [6] since there must be space for living quarters. In this instance, the radial velocity, V_*, also equals the maximum Doppler velocity as we assume the inclination of the Death Star's orbit is perpendicular to the line of sight.

Results

Using equation (1), we calculated the drop in the flux from the star, Δf to be $1.3\text{x}10^{-6}$%. Although tiny, this can be expected since, for example, Earth causes a Δf of $8.4\text{x}10^{-3}$% as it transits the Sun, many orders of magnitude greater [7].

Through combining equations (2) and (3) to find equation (4), we found that the radial velocity, V_*, to be $1.53\text{x}10^{-7}\text{ms}^{-1}$. By comparison, the exoplanet Alpha Centauri Bb, has a radial velocity of 0.51ms^{-1} [8].

In our calculations, we have assumed that the Death Star II acts like an exoplanet in a stable orbit of 1AU around a star. We have assumed the Endor system has a single star, and that this star is similar to that of our own Sun.

Discussion

Currently, the best telescope that we have to detect exoplanets is the Kepler Spacecraft, which has so far detected 2,331 confirmed exoplanets as of October 19th 2016 [9]. The smallest exoplanet that Kepler has confirmed, Kepler-37b, is slightly larger than our own Moon, at a radius of almost 2000km [10]. It is reasonable to assume that for the Death Star II to be detected by transit photometry, it would have to be at least the size of Kepler-37b, or have a radius 25 times its current radius. In terms of radial velocity, the lightest exoplanet discovered only has a mass of 1.9 Earth masses [11]. To be detected by this method, we can assume that the Death Star II would have to be over ten orders of mass greater.

Under current methods of exoplanet detection, the Death Star II is impossible to detect, but in the future we may be able to really say "That's no moon, it's a space station!"

References

[1] `http://starwars.wikia.com/wiki/Death_Star_II` accessed on 14/11/2016

[2] `https://en.wikipedia.org/wiki/Methods_of_detecting_exoplanets` accessed on 14/11/2016

[3] Dr Matt Burleigh (2015), *Extrasolar Planets Lecture 2* [Lecture to MPhys and BSc Physics], PA3677: Life In The Universe, University of Leicester, October/November 2015

[4] `https://en.wikipedia.org/wiki/Sun` accessed on 14/11/2016

[5] `https://en.wikipedia.org/wiki/Doppler_spectroscopy` accessed on 14/11/2016

[6] `http://www.engineeringtoolbox.com/metal-alloys-densities-d_50.html` accessed on 14/11/2016

[7] `https://kepler.nasa.gov/science/about/characteristicsoftransits/index.cfm` accessed on 14/11/2016

[8] `http://www.eso.org/public/news/eso1241/` accessed on 14/11/2016

[9] `https://www.nasa.gov/kepler/discoveries` accessed on 14/11/2016

[10] `http://www.nasa.gov/mission_pages/kepler/news/kepler-37b.html` accessed on 14/11/2016

[11] `https://www.eso.org/public/news/eso0915/` accessed on 14/11/2016